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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Mr. William Caton Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, DC 20554

Attn: International Bureau

Re: Leo One USA Corporation
IC Docket No. 94-31

DOCKET FILE COPY ORIGINAL

Dear Mr. Caton:

Leo One USA Corporation, by counsel, hereby submits the attached Supplemental Comments in the above-captioned proceeding. These Supplemental Comments contain a technical analysis on sharing between MSS below 1 GHz uplinks and land mobile receivers. If there are any questions regarding the methodology, assumptions, analyses or conclusions in this Report, please contact the undersigned at (202) 463-4645.

Very truly yours,

Robert A. Mazer /by SS

Robert A. Mazer
Counsel to Leo One USA
Corporation

RAM/aod

RECEIVED

JUL 6 1995

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Preparation for International	)	IC Docket No. 94-31
Telecommunication Union World	)	
Radiocommunication Conferences	)	

SUPPLEMENTAL COMMENTS
OF
LEO ONE USA CORPORATION

Leo One USA Corporation ("Leo One USA"), by counsel, hereby submits these Supplemental Comments in the above-captioned proceeding. Leo One USA is a pending applicant for a mobile satellite service ("MSS") below 1 GHz system. It has actively participated in this proceeding including the submission of Comments and Reply Comments. In its Reply Comments, Leo One USA indicated that it was undertaking detailed sharing studies for MSS below 1 GHz systems and that the results of those studies would be forwarded to the Commission when complete. It believed that these studies were necessary in order to eliminate much of the confusion that currently exists on how MSS below 1 GHz SDMA systems can successfully share with land mobile operations in the uplink and with various other services in the downlink. The Uplink Report is now finished and is being submitted herewith.[1]

Initially, Leo One USA would like to applaud the efforts made by the FCC and the United States government in developing proposals for the World Radiocommunications

---

[1] The Downlink Report will be forwarded to the Commission in several days.

Conference ("WRC-95") We are particularly pleased by the proposals for additional spectrum allocations to the MSS below 1 GHz service. The FCC proposed an allocation of 4 MHz in the space-to-Earth direction and 2.150 in the Earth-to-space direction for MSS below 1 GHz systems.

Although these proposals go a long way toward meeting the downlink requirements for this new innovative service, Leo One USA believes that access to additional uplink spectrum is critical. Specifically, if present market projections for the MSS below 1 GHz service are to be met, Leo One USA believes that it is necessary for WRC-95 to allocate at least 5 MHz of uplink spectrum. This is consistent with the conclusion of the Conference Preparatory Meeting which indicated that 7-10 MHz of additional spectrum was needed in the near future. Otherwise, new systems may not have access to enough spectrum to ensure commercial viability.[2]

As stated in its previous Comments, Leo One USA believes that MSS below 1 GHz systems can successfully share with land mobile operations.[3] The attached Uplink Report substantiates this conclusion.[4] This uplink sharing analysis was conducted by LinCom Corporation, an independent systems engineering firm with a 20-year history in the satellite industry and a major contributor to the advancement of satellite communications technology through its participation in programs such as Milstar, The Space Station Freedom, the Space

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[2] FDMA systems need enough bandwidth to find a sufficient number of open channels while CDMA systems need to spread their signal over a large enough bandwidth in order to provide a commercially viable data rate.

[3] See Comments of Leo One USA in IC Docket No. 94-31 at 9, March 6, 1995.

[4] Since Leo One USA proposes to operate an FDMA system, this Uplink Report only evaluates sharing between FDMA and land mobile systems.

Shuttle, and the TDRSS/ATDRSS. This study was designed to analyze the feasibility of co-frequency sharing between mobile satellite service uplinks and land mobile services.[5] The narrowband (FDMA/TDMA) uplink transmissions of the Leo One USA MSS system were simulated in the presence of land mobile transmissions to determine the availability of channels for the Leo One USA system and the probability of interference to land mobile users. The results of this study can be generalized to multiple narrowband MSS systems simultaneously co-frequency sharing with land mobile services.

The study used dynamic, stochastic models of both Leo One USA and land mobile units to provide a high fidelity analysis of the co-frequency sharing potential between MSS systems and land mobile services. An overview of the results is summarized below.

- **Co-frequency sharing between narrowband MSS below 1 GHz systems and land mobile services will allow the MSS below 1 GHz systems to find clear channels.**
  - Assuming 1 MHz of available spectrum, a 25 KHz land mobile channelization plan, and 9.6 kbps Leo One USA uplink channels, an average of 6 clear uplink channels will be available per satellite in the presence of up to 240,000 land mobile users across CONUS, assuming an average activity factor for the land mobile users.
  - Assuming 1 MHz of available spectrum, a 6.25 KHz land mobile channelization plan, and 2.4 kbps Leo One USA uplink channels, an average of 6 clear uplink channels will be available per satellite in the presence of up to 1.92 million land mobile users in the CONUS, assuming an average activity factor for the land mobile users.
  - The results scale approximately linearly as more, or less, spectrum is available to the MSS system. For example, assuming 5 MHz of available spectrum, a 6.25 KHz land mobile channelization plan and 2.4 kbps Leo One USA uplink channels, an average of 30 clear uplink channels will be available per satellite

[5] This Report uses Recommendation ITU-R M 1039 (Method For Evaluating Sharing between systems in the Land Mobile Service below 1 GHz and FDMA MSS Mobile Earth Stations) as a basis for its analyses.

for up to 9.6 million land mobile users in the CONUS, depending on the land mobile average activity factor.

- **Co-frequency sharing between narrowband MSS systems and Land Mobile services will result in negligible interference into Land Mobile users.**

IF NO USE OF DYNAMIC CHANNEL ALLOCATION ASSIGNMENT SYSTEM (DCAAS)

- For operation in 1 MHz of spectrum with random uplink channel assignment (NO avoidance of active channels), the probability of interference into a given land mobile user is 0.0002, which is equivalent to 1 second of interference, a pop or click, for every 83 minutes of on-air operation.

- If Leo One USA's uplinks were operating in 5 MHz of spectrum a given land mobile user would experience an average of 1 second of interference for every 7 hours of on-air operation for completely random Leo One USA uplink channel assignment.

IF DCASS IS USED

- When dynamic channel assignment is used to avoid channels actively being used by land mobile receivers, the interference from Leo One USA transceivers into a given Land Mobile receiver will be virtually nonexistent.

The results of the LinCom analysis indicate that narrowband MSS below 1 GHz systems can successfully share spectrum with land mobile services. Furthermore, the refarming of land mobile channels into a narrower channel plan does not inhibit the ability of MSS below 1 GHz systems to successfully share this spectrum.

Leo One USA believes this Report further substantiates the ITU-R's previous conclusion that MSS below 1 GHz systems can successfully share with land mobile users. In a co-sharing situation, enough channels will be available to insure commercially viable MSS below 1 GHz systems. Equally important, when DCAAS is used there will virtually not be any interference to the land mobile service. Given this conclusion and the need for a total of 5 MHz of uplink spectrum at WRC-95, Leo One USA urges the U.S. government to immediately propose the allocation of at least 3 MHz of land mobile spectrum (e.g., 456-459 MHz) for MSS below 1 GHz uplinks in addition to the 2 MHz proposed in the Commission's June 15, 1995 Report.

Respectfully submitted,

Robert A. Mazer / by SS

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Dated: July 6, 1995

Attorney for Leo One USA Corporation

CERTIFICATE OF SERVICE

I, Shelley Sadowsky, do hereby certify that a true and correct copy of the foregoing "Supplemental Comments" was sent by first-class mail, postage prepaid, or hand-delivered, on this 6th day of July, 1995, to the following persons.

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* Via Hand Delivery

Leo One USA

Uplink Band

Sharing Analysis

Part 2

Prepared by:

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Mark A. Sturza
Erik Goldman
LEO One USA

June 21, 1995

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LinCom CORPORATION

Leo One USA Uplink Band Sharing Analysis - Part 2

1.0 Introduction and Summary

This study analyzes the feasibility of co-frequency sharing between non-voice non-geostationary (NVNG) mobile satellite service (MSS) uplinks and Land Mobile services. The narrowband (FDMA/TDMA) uplink transmissions of the Leo One USA NVNG MSS system were simulated in the presence of Land Mobile transmissions to determine the availability of channels for the Leo One USA system and the probability of interference to Land Mobile users. The results of this study can be generalized to multiple narrowband NVNG MSS systems simultaneously co-frequency sharing with Land Mobile services.

Leo One USA proposes to operate its subscriber uplinks in the 148.905 - 150.05 MHz band. Land Mobile Transceivers operate in the 148 - 149.9 MHz band. Thus there is the potential for interference, both from Land Mobile Transceivers into Leo One USA Satellites and from Leo One USA Transceivers into Land Mobile Transceivers. Other bands from 100 MHz to 500 MHz that are used by Land Mobile Transceivers are also being considered for "Little LEO" uplinks.

A previous report[1] used static, deterministic models to analyze the sharing potential in the 148 - 149.9 MHz band and determine the interference sensitivity to operation in other potential "Little LEO" bands. It showed that "Leo One USA can successfully operate its uplinks in Land Mobile bands in the 100 MHz to 500 MHz range and can co-exist with Land Mobile Transceivers operating with a variety of channelization plans." The results of that report are summarized in Section 2.

This report uses dynamic, stochastic models to provide higher fidelity analysis of the co-frequency sharing potential between NVNG MSS systems and Land Mobile services. Section 3 describes the models used. The analysis and simulation results are presented in Sections 4 and 5 for the interference into Leo One USA satellites and the interference into Land Mobile users, respectively.

Section 4 shows that co-frequency sharing between narrowband NVNG MSS systems and Land Mobile services will allow the NVNG MSS to find clear channels.

- Assuming 1 MHz of available spectrum, a 25 KHz Land Mobile channelization plan, and 9.6 kbps Leo One USA uplink channels, an average of 6 clear uplink channels will be available per satellite in the presence of up to 240,000 Land Mobile users in the CONUS, depending on Land Mobile average activity factor.
- Assuming 1 MHz of available spectrum, 6.25 KHz Land Mobile channelization plan, and 2.4 kbps Leo One USA uplink channels, an average of 6 clear uplink channels will be available per satellite in the presence of up to 1.92 million Land Mobile users in the CONUS, depending on Land Mobile average activity factor.

[1] M. Sturza, M. Yang, H. Woo, "Leo One USA Uplink Band Interference Analysis Report", 12 April 1995.

- In both of the above cases, the average waiting time for a given Leo One USA transceiver to have a clear channel available is less then 40 seconds.
- The above results scale approximately linearly with available spectrum. For example, assuming 5 MHz of available spectrum, a 6.25 KHz Land Mobile channelization plan and 2.4 kbps Leo One USA uplink channels, an average of 30 clear uplink channels will be available in the presence of up to 9.6 million Land Mobile users in the CONUS, depending on Land Mobile average activity factor.

Section 5 shows that co-frequency sharing between narrowband NVNG MSS systems and Land Mobile services will result in negligible interference into Land Mobile users.

- For operation in 1 MHz of spectrum with random uplink channel assignment (no avoidance of active channels), the probability of interference into a given Land Mobile user is 0.0002, which is equivalent to 1 second of interference, pops or clicks, for every 83 minutes of on-air operation.
- Restricting the Leo One USA uplink channel assignments to interstitial channels reduces the interference to 1 second for every 15 hours of on-air operation.
- If Leo One USA's uplinks were operating in 5 MHz of spectrum a given Land Mobile user would experience an average of 1 second of interference for every 7 hours of on-air operation for completely random Leo One USA uplink channel assignment.
- This interference is reduced to one second every 70 hours of on-air operation if the random assignments are restricted to interstitial channels.
- When dynamic channel assignment is used to avoid channels actively being used by Land Mobile Transceivers, the interference from Leo One USA Transceivers into a given Land Mobile receiver is negligible.

The results of this study show that narrowband NVNG MSS systems can successfully share spectrum with Land Mobile services.

2.0 Review of Results from Previous Report

The analysis and simulation results provided in the previous report are summarized in the following sections. These results were obtained using static, deterministic models. They do not account for Leo One USA constellation dynamics, the geographical distribution of Leo One USA transceivers and of Land Mobile transceivers, or for the Leo One USA transceiver and Land Mobile transceiver activity factors. As crude as the results are they clearly demonstrate that there is a positive potential for co-frequency sharing between the Leo One USA NVNG MSS and Land Mobile services.

2.1 Interference from Land Mobile Transceivers into Leo One USA Satellites

Simulations were performed to determine the number of and the probability of being able to find clear channels. Four Land Mobile channelization plans were considered:

- 12.5 KHz spacing with 8 KHz IF bandwidth FM signal
- 15 KHz spacing with 8 KHz IF bandwidth FM signal
- 25 KHz spacing with 16 KHz IF bandwidth FM signal
- 30 KHz spacing with 16 KHz IF bandwidth FM signal

Three Leo One USA channel bandwidths were considered (2.4 kbps, 4.8 kbps, 9.6 kbps). The worst interference was shown to occur when both of the systems are using the widest bandwidths (16 kHz IF for Land Mobile and 9.6 kbps uplink bandwidth for Leo One USA).

Figures 2-1 and 2-2 show the median and 90-th percentile number of clear channels as a function of the number of Land Mobile Transceivers simultaneously active in a given 1/2-second interval, respectively. Figures 2-3 and 2-4 show the probability of being able to find 15 clear channels as a function of the number of simultaneously active Land Mobile Transceivers for different operating frequency bands and for different I_0/N_0 thresholds, respectively.

The results show that:

- The probability of finding 15 clear channels increases for smaller LEO One USA channel sizes for the same number of Land Mobile Transceivers simultaneously active in a given 1/2-second interval.
- For a given amount of spectrum, 1.9 MHz, the probabilities of finding 15 clear channels are similar for the 148 - 149.9 MHz, 312 - 315 MHz, and the 450 - 460 MHz bands for the same number of Land Mobile Transceivers simultaneously active in a given 1/2-second interval.

- The probability of finding 15 clear channels is significantly better for smaller Land Mobile Transceiver channels assuming the same number of Land Mobile Transceivers simultaneously active in a given 1/2-second interval.

2.2 Interference from Leo One USA Transceivers into Land Mobile Transceivers

Analyses were performed to evaluate the interference from Leo One USA Transceivers into Land Mobile Transceivers. Figure 2-5 shows that a Leo One USA Transceiver could interfere (C/I<10.7dB) with a given Land Mobile user if they are less then 47 km apart, they are operating at exactly the same frequency, and the Land Mobile user is operating at threshold, i.e. minimum received signal level. These assumptions are pessimistic, the actual interference probability will be extremely low, as shown in Section 5. Figure 2-6 shows the percentage area of a satellite footprint subject to potential interference from Leo One USA Transceivers at any instant in time.

The results show that:

- Operating in the interstitial channels significantly reduces interference for all of the data rates considered (9.6 kbps, 4.8 kbps, and 2.4 kbps).
- The lower the data rate, the smaller the potential interference distance.
- For the worst case of 15 active LEO USA Transceivers operating at 9.6 kbps at the Land Mobile Transceiver center frequencies, only 2.6% of the satellite footprint area is potentially effected. Operating at the interstitial frequencies reduces the area to less then 0.2%.
- The required separation distance for a given C/I threshold decreases with increasing frequency.

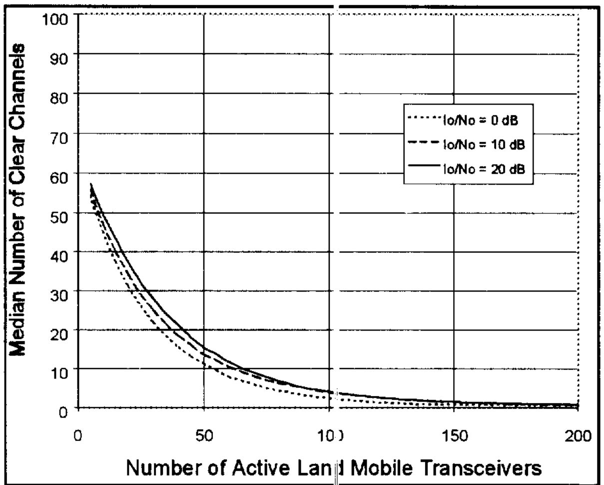

Figure 2-1. Median Number of Clear 15 kHz Channels for 25 kHz Land Mobile Grid

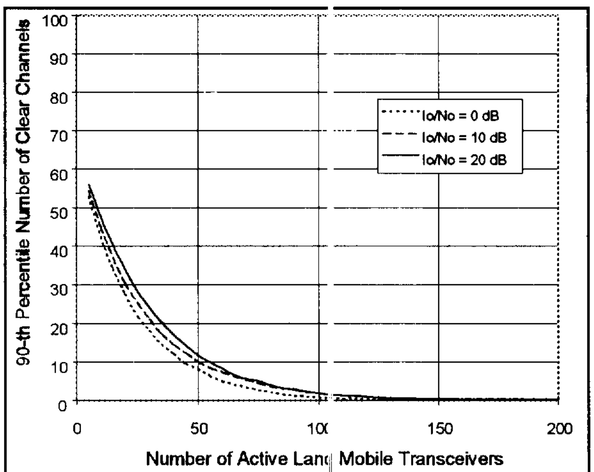

Figure 2-2. 90-th Percentile Number of Clear 15 kHz Channels for 25 kHz Land Mobile Grid

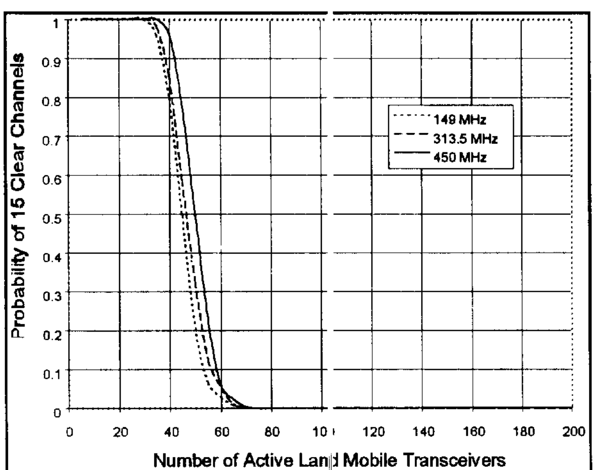

Figure 2-3. Probability of 15 Clear 15 kHz Channels With $I_0/N_0 < 10$ dB for 25 kHz Land Mobile Channelization

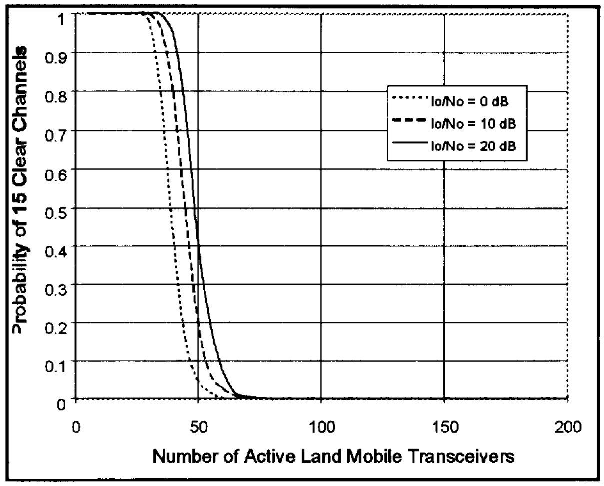

Figure 2-4. Probability of 15 Clear 15 kHz Channels for 25 kHz Land Mobile Grid

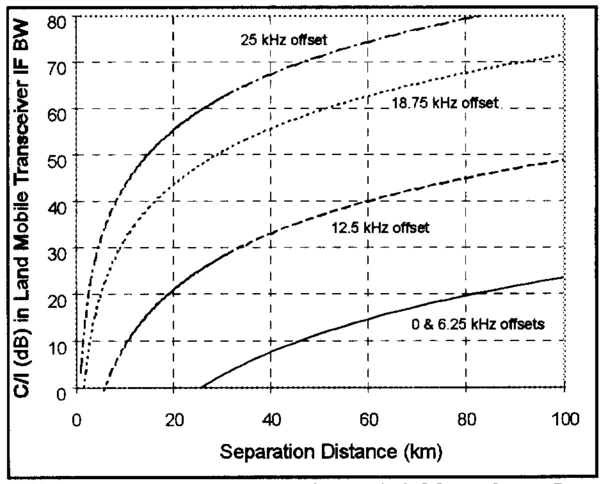

Figure 2-5. Interference from 9.6 kbps Leo One USA Transceiver into Land Mobile Transceiver

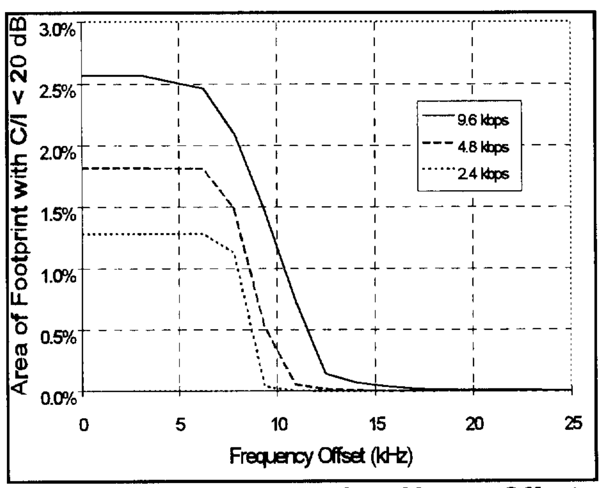

Figure 2-6. Interference Area Versus Offset For 15 Active Leo One USA Transceivers

3.0 Simulation Models

The simulation models used in this report are described in the following sections.

3.1 Leo One USA Constellation

The Leo One USA constellation consists of a total of 48 satellites in eight orbital planes equally spaced around the equator and inclined at 50°. Each plane contains six equally spaced satellites in 950 km altitude circular orbits. The constellation dynamics are modeled using a Monte-Carlo simulation with a 1/2-second step size. The relevant satellite parameters are as follows:

- 15° elevation mask angle
- circular polarized iso-flux antenna pattern
- G/T of -30.6 dB/°K at the sub-satellite point
- nominal 15 kHz uplink channel bandwidth corresponding to a 9.6 kbps user burst rate
- 1 MHz uplink band with 2.5 kHz center frequency spacing

3.2 Leo One USA Transceivers

The Leo One USA NVNG MSS is modeled as 200 traffic spots distributed over the continental United States (CONUS) in accordance with population density. Each traffic spot represents 1,000 Leo One USA transceivers for a total of 200,000 transceivers. The traffic spots independently generate Poisson/exponential Monitoring packet transmissions resulting in an average activity of 4.7 packets per day per user, equivalent to an average activity factor of 5.4×10^{-6}.

The results presented in this report correspond to a product of total population and activity factor equal to 1.1. Identical results would be obtained for any other combination of number of Leo One USA users in the CONUS and average activity factor that have the same product. For example, the results shown in this report also represent those for 20,000 Leo One USA users with an average activity of 47 packets per day, or 2 million users with an average activity of 1 packet every two days.

The theoretical peak monitoring packet uplink capacity of the Leo One USA system over the CONUS in 1 MHz of available spectrum is a product of total population and activity factor equal to 23.8. For example, 10 million users with an average activity factor of 2.4×10^{-6}, equivalent to an average activity of 2 Monitoring packets per day.

The Leo One USA Transceivers are modeled as follows:

- 1 MHz uplink band with 2.5 kHz center frequency spacing
- 0 dBi vertically polarized antenna
- 9.6 kbps data rate
- 7 W transmit power
- 99% power containment bandwidth of 8.2 kHz (Figure 3-1):

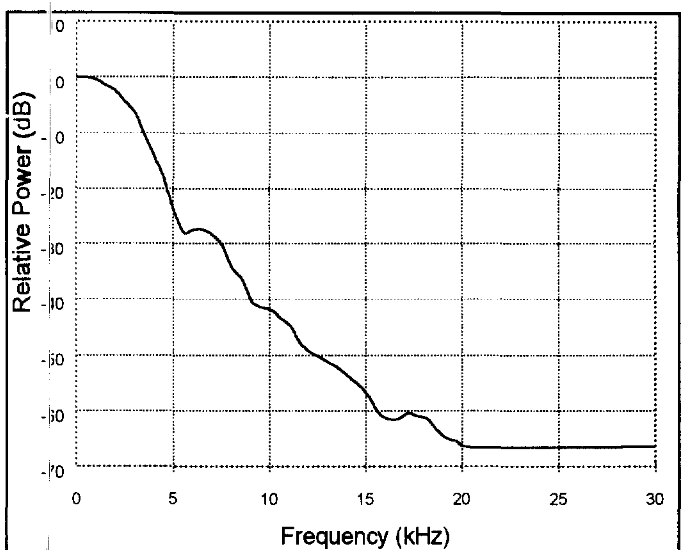

Figure 3-1. Leo One USA Transceiver Transmit Signal Mask

3.3 Land Mobile

The Land Mobile service is modeled as 200 traffic spots distributed over the CONUS in accordance with information contained in the FCC's license data base. The number of Land Mobile Transceivers per traffic spot is varied from 400 to 1,200 to evaluate the sensitivity to Land Mobile traffic level. This simulates a total population of Land Mobile users that varies from 80,000 to 240,000. Each traffic spot independently generates Poisson/exponential transmissions with random transmission duration resulting in an average activity factor of 0.001.

The results presented in this report correspond to a product of total population and activity factor that ranges from 80 to 240. Identical results would be obtained for any other combination of number of Land Mobile users in the CONUS and average activity factor that have the same product. For example, the results shown in this report as corresponding to 240,000 Land Mobile users in the CONUS also represent those for 24,000 Land Mobile users with an average activity factor of 0.01, or 2.4 million users with an average activity factor of 0.0001.

The Land Mobile Transceivers are modeled as follows:

- 1 MHz band with 25 KHz channelization (40 channels)
- 16 KHz FM signal bandwidth (Figure 3-2)
- 14 dBW (25 W) transmit power
- 6 dBi vertically polarized antenna (0 dBi in direction of satellite)
- 16 kHz IF receive bandwidth
- -140 dBW minimum received signal power at edge of coverage
- FM threshold at C/(N+I) = 10.7 dB.

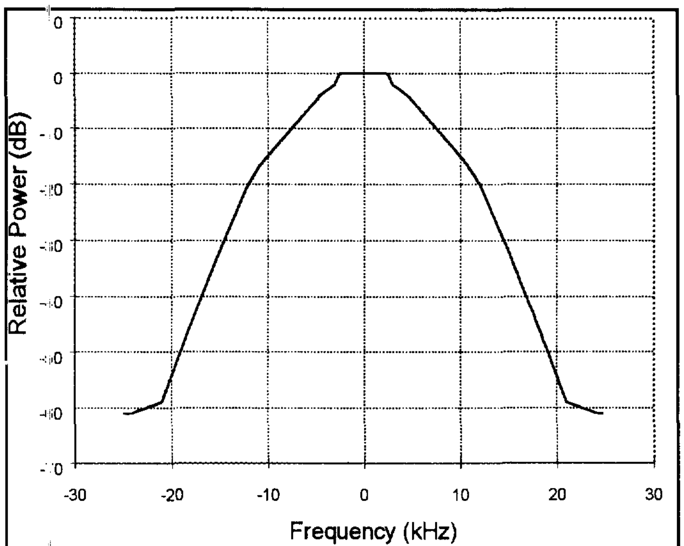

Figure 3-2. Land Mobile Transceiver Transmit FM Signal Mask

4.0 Interference from Land Mobile Transceivers into Leo One USA Satellites

Figure 4-1 shows the cumulative probability for the number of clear 9.6 kbps uplink channels per satellite assuming 1 MHz of available spectrum for various numbers of Land Mobile Transceivers operating with a 25 KHz channelization plan. For example, if there are 80,000 Land Mobile Transceivers in the CONUS, then the probability of finding 6 or more clear uplink channels is about 0.98. The probability decreases to 0.55 when there are 240,000[2] Land Mobile Transceivers.

Figure 4-2 shows the average number of clear 9.6 kbps uplink channels as a function of the number of Land Mobile Transceivers in the CONUS. For example, if there are 240,000 Land Mobile Transceivers in the CONUS, then on average 6 uplink channels will be available per satellite. As shown in the previous report, the number of Land Mobile Transceivers that results in a given number of clear 2.4 kbps uplink channels being available is approximately twice that as for a given number of 9.6 kbps channels. For example, if there are 480,000 Land Mobile Transceivers in the CONUS, then on average six 2.4 kbps uplink channels will be available per satellite.

Also as shown in the previous report, the number of Land Mobile Transceivers that results in a given number of clear uplink channels being available varies approximately linearly with the size of the Land Mobile channels. For example, if there are 1.92 million Land Mobile Transceivers in the CONUS operating with a 6.25 KHz channelization plan, then on average six 2.4 kbps uplink channels will be available per satellite.

Figure 4-3 shows the probability of no clear channels being available, Figure 4-4 shows the probability of successful transmission, and Figure 4-5 shows the average waiting time. All of these figures assume 1 MHz of available spectrum and all of the results can be scaled with Leo One USA channel rate and with Land Mobile channel spacing. For up to 240,000 Land Mobile Transceivers in the CONUS, the average waiting time for a given Leo One USA transceiver to have a clear channel available is less then 40 seconds.

Figure 4-6 shows the average number of clear channels per satellite for operation in the 149 - 150 MHz and 455 - 456 MHz bands. The Doppler shift in the higher frequency band is more severe and thus the number of clear channels per satellite is slightly reduced.

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[2] The 240,000 Land Mobile Transceivers in the CONUS are modeled as operating with an average activity factor of 0.001. Identical results would be obtained for any other combination of number of Land Mobile Transceivers in the CONUS and average activity factor that have a product of 240. For example, 24,000 Land Mobile Transceivers with an average activity factor of 0.01, or 2.4 million with 0.0001.

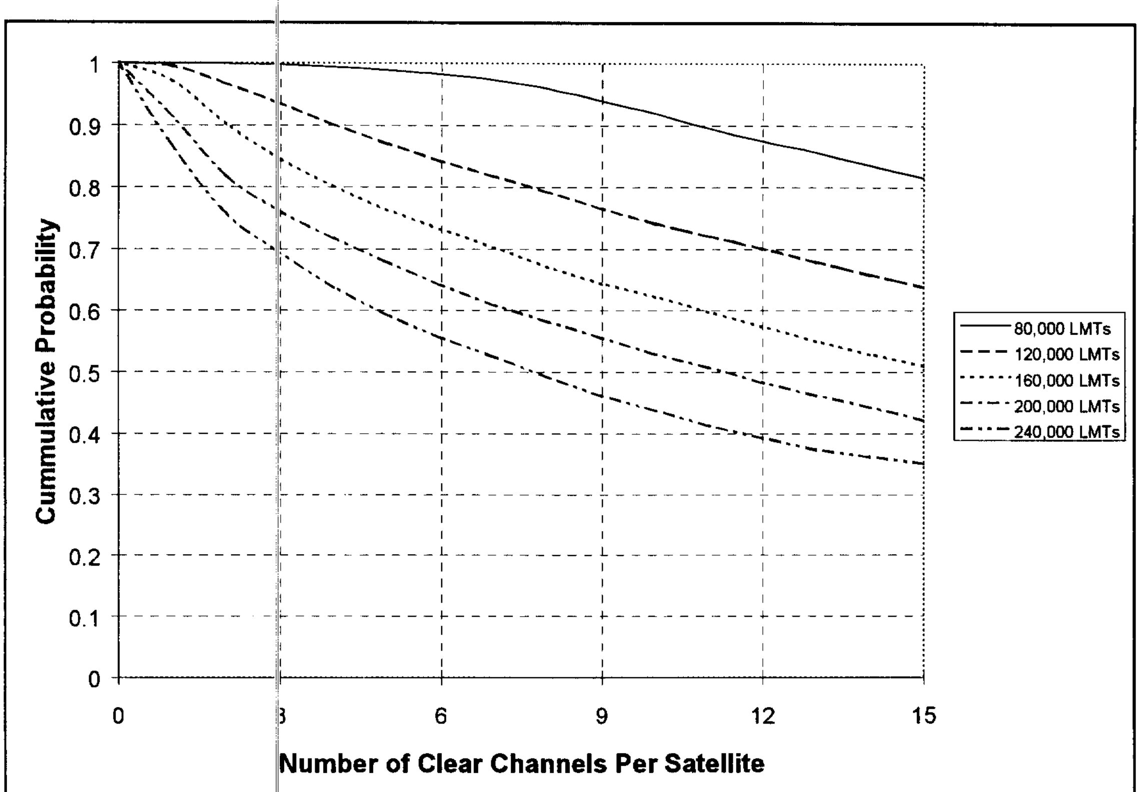

Figure 4-1. Cumulative Probability of Number of Clear Channels in 1 MHz Bandwidth for Various Number of Land Mobile Transceivers (LMTs) in the CONUS

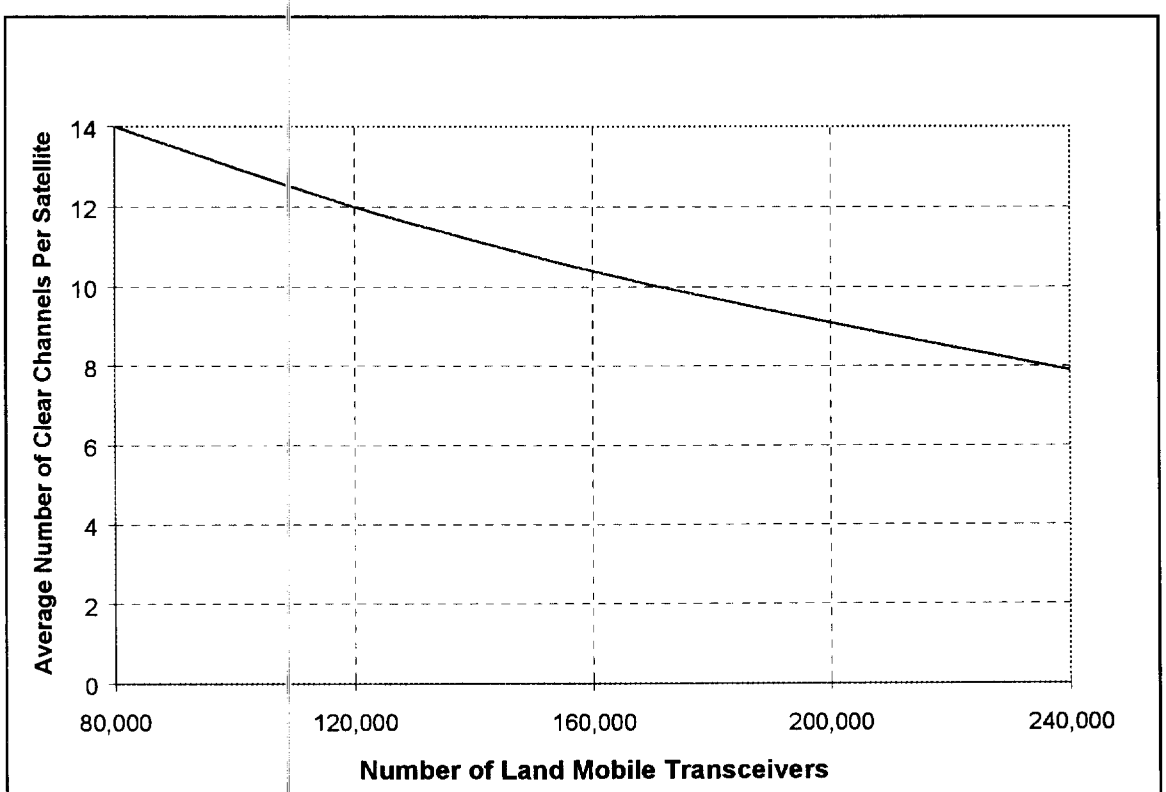

Figure 4-2. Average Number of Clear Channels Per Satellite in 1 MHz Bandwidth

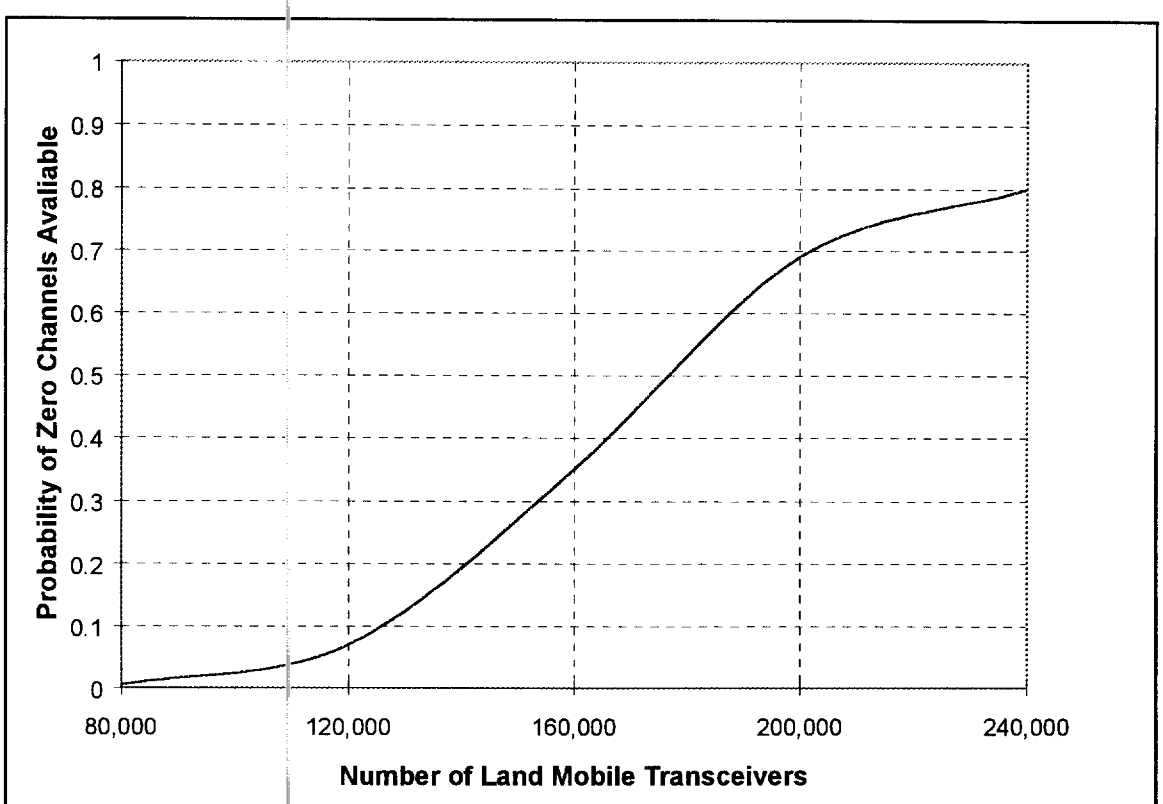

Figure 4-3. Probability of Zero Clear Channels Being Available in a 1 MHz Bandwidth

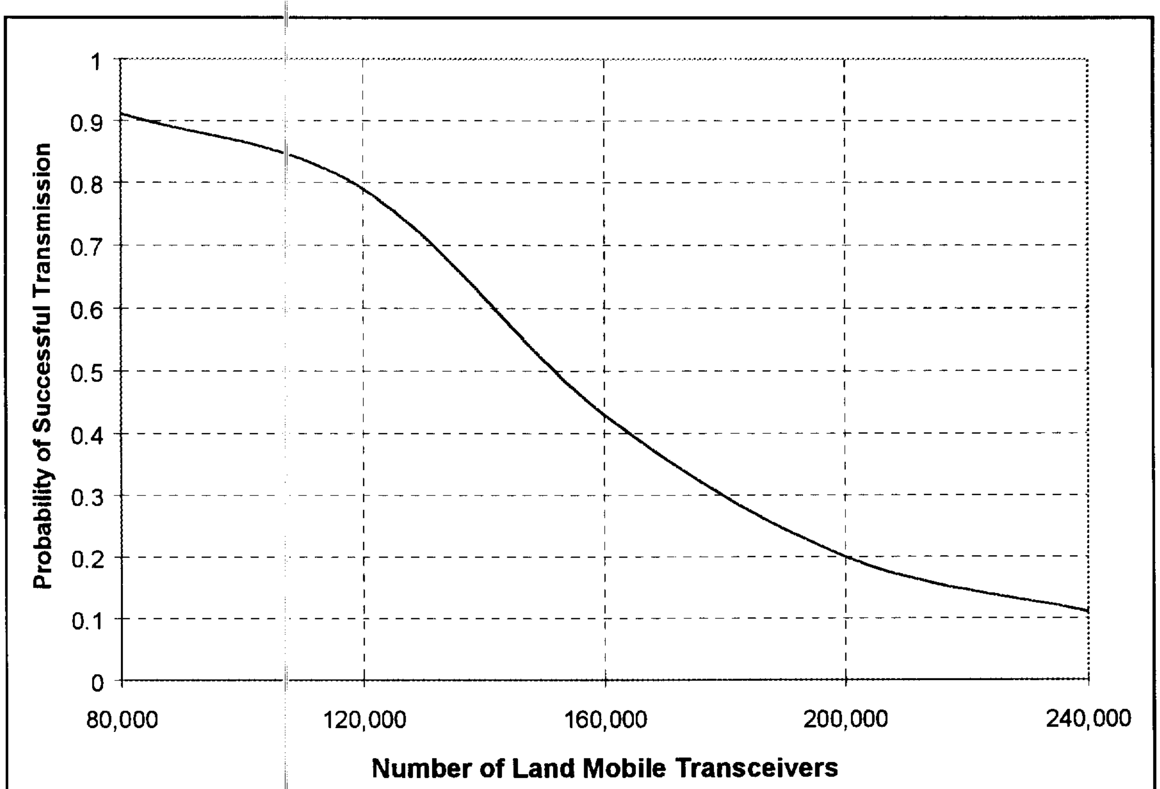

Figure 4-4. Probability of Successful Transmission (1 MHz Bandwidth)

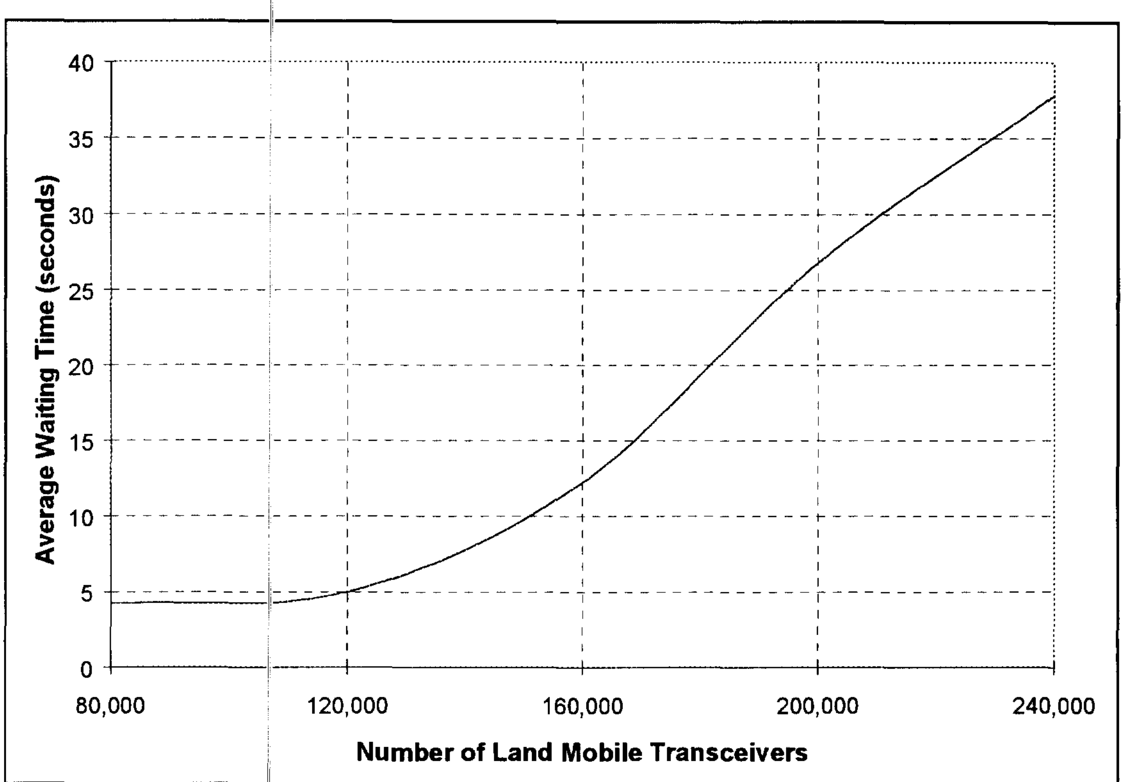

Figure 4-5. Average Waiting Time (1 MHz Bandwidth)

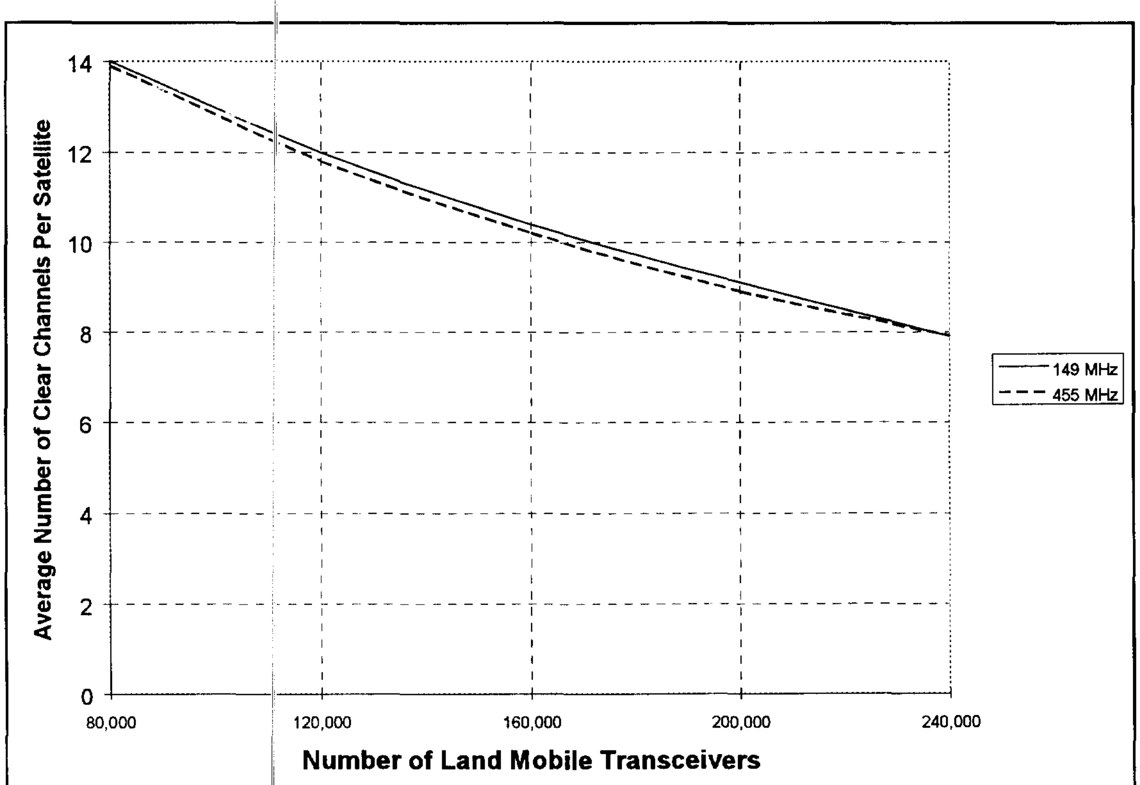

Figure 4-6. Average Number of Clear Channels in a 1 MHz Bandwidth For Different Frequency Bands